



# **Inspire the Next Generation of Earth Explorers:**

## **A Plan for Contributing to NASA Mission Success**

National Aeronautics and Space Administration  
Earth Science Enterprise  
NASA Headquarters  
Washington, DC 20546

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## ***Foreword***

We stand today with a renewed focus on education.

Behind us lies more than forty years of exploration of the Earth from the vantage point of space. The fabulous suite of observations of practically every aspect of the Earth, particularly over the last decade, provide a revolutionary new perspective on the Earth, enabling us to see, explore, and investigate our world in ways never before possible. The concept of the Earth as a rich and complex system of interconnected components and processes has become a dominant paradigm in scientific research. Upon this foundation lies the opportunity for Earth Science to serve the national interest by understanding and protecting our home planet. Yet, the intellectual capital to realize this opportunity relies on proficient scientific literacy of all the American adults and effective science education for all of our children.

NASA Administrator O'Keefe and all members of the Agency have come to recognize the role space exploration plays in science education by making "*To inspire the next generation of explorers....as only NASA can*" a core element of NASA mission. The immense importance of this action and the creation of an Education Enterprise have led to the first Education Strategy for the Agency, a framework by which we intend to fulfill our mission.

The new NASA Education Strategy, expanding knowledge in how people learn, and community-wide interest in revolutionizing Earth and space science education have led us to develop "*Inspire the Next Generation of Earth Explorers*." This document builds on our success in Earth Science Education since the first publication of the Earth Science Education Strategy in 1996; it aligns with the new framework set forth in the NASA Education Strategy; it also recognizes the new educational opportunities resulting from the accomplishments that the Earth Science Enterprise has made over the last decade in studying the Earth as a system. The document embodies comprehensive, practicable plans for the Earth Science Enterprise to not only inspire our children but also provide educators with the tools they need to teach math and science and to improve our citizens' scientific literacy.

The plan, "*Inspire the Next Generation of Earth Explorers*", directs us to systematically identify opportunities that embrace the full spectrum of ways in accessing knowledge; to develop the most effective strategies to achieve tangible, lasting results; and to work collaboratively to catalyze action at a scale great enough to ensure impact at the national level. The plan will continue to be an evolving document, reviewed and updated periodically in a partnership between the Earth Science and Education Enterprises.

With this renewed focus, we stand together with many friends and colleagues around the world in a mutual commitment to understanding and protecting our home planet.

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## EXECUTIVE SUMMARY

The NASA Vision is

- To improve life here
- To extend life to there
- To find life beyond

The NASA Mission is

- To understand and protect our home planet
- To explore the universe and search for life
- To inspire the next generation of explorers
- ....as only NASA can

The Earth Science Enterprise (ESE) has a *leading* role in NASA's mission to understand and protect our home planet, a *supporting* role in NASA's mission to explore the universe and search for life and an *essential* role in NASA's mission to inspire the next generation of explorers. The Earth system science concept pioneered by NASA has changed how Earth science research is conducted and is revolutionize the way Earth science is taught at elementary through post-graduate levels.

The plan described herein sets forth the direction for how practitioners in the Earth Science Enterprise contribute to the Agency's Education mission for the ten year time period 2003-2012. The introductory chapter highlights the unique contributions that ESE brings to education; the accomplishments that NASA has made in science, technology, engineering, mathematics (STEM), and geography education; as well as new opportunities for ESE to make substantive contribution to Agency performance in education and achieve tangible, lasting results. Chapter II provides the Agency objectives and outcomes for education and highlights the specific roles that ESE plays. Also included in this Chapter are essential quality indicators for educational activities NASA-wide. Chapter III describes the approach that ESE will take to enable networked data and information systems for learning purposes and networked communities for catalyzing action at a scale great enough to ensure impact at the national scale. Chapter IV gives preliminary performance measures that ESE is accountable for its investments. The final Chapter summarizes governance and management that supports the essential role that ESE has in education and the internal and external partnerships for accomplishing the common purpose.

This document is designed to be both living and active. It will change as customer and program needs dictate. Updates to reflect new directions will occur on a three year cycle.

## I. INTRODUCTION

### *Earth Science Enterprise*

Earth Science is science in the national interest. Using the vantage point of space, NASA has laid a solid scientific and technological foundation over the past 40 years, enabling the Earth Science Enterprise to play a leading role in NASA's mission to understand and protect our home planet. NASA's Earth observing satellites and sponsored research programs have led scientists to view the Earth as a system – as a dynamic set of interactions among continents, atmosphere, oceans, ice, and life. This profound realization gave rise to the birth of the new interdisciplinary field of Earth system science. Earth system science pursues answers to critical societal questions: *How is the Earth changing? What are the consequences for life on Earth?* Toward increased knowledge of Earth system processes, the Earth Science Enterprise collects over 2 TB of information on geophysical parameters daily using 80 sensors operating on 18 Earth observing spacecraft. This data drives models which predict Earth's evolution. Output from the geophysical models drive decision support tools which assist decision makers and result in enhanced socioeconomic benefit. These advances in Earth system science can only be sustained and fully utilized by an educated citizenry.

### *Science Education*

The National Science Education Standards (NSES) published by the National Research Council (NRC, 1996) and the Benchmarks for Scientific Literacy published by the American Association for the Advancement of Science (AAAS, 1993) present two independent and cohesive visions for science education. Both documents advocate inquiry-based learning as a path towards scientific literacy. At the same time, the importance of Earth science to the future of our planet is receiving increased recognition. The NSES have adopted a system perspective for Earth science education. The American Geophysical Union, the foremost professional society for advancing Earth science research, has endorsed the recommendations of both the NRC and the AAAS for science education. The National Science Foundation, through its sponsorship of the National Conference on the Revolution in Earth and Space Science Education is calling for a reconsideration of how Earth science is taught and perceived. Blueprint for Change (REF), published as a result of the conference, recommends stronger emphasis on understanding Earth as a system along with inquiry-based learning and the use of visualization technologies. Leading research universities are establishing Earth system science departments and research labs emphasizing an academic commitment to the interdisciplinary demands of Earth system science research and education. Within our own Agency, education has been elevated to the Enterprise level, in recognition of the valuable and unique contributions NASA has to offer STEM and geography education.

### *Earth Science Enterprise Education Program*

The increased national emphasis on ESS education in combination with our constantly evolving scientific understanding of the Earth system, large arrays of geophysical data, and technological advances for collecting and analyzing this data present valuable opportunities to our Education Program for contributing to and informing instructional practice. The demonstrated need for inquiry-based and Earth system education at all levels also presents new challenges to the Enterprise for reaching the increasing

community of Earth system learners. While it is an enormous and costly endeavor to directly reach each citizen, NASA has the human and technological resources to indirectly reach broad and diverse audiences by systematically delivering Enterprise resources to the formal and informal education communities through networked information systems and networked communities. Working in close collaboration with the Education Enterprise, the ESE Education Program contributes to the national science education agenda to improve STEM and geography education by providing unique STEM content within an inquiry-based Earth system context. The ESE Education Program also works with the Education Enterprise to engage students in the latest technologies within an Earth system science context and prepare them for careers in Earth system science fields.

#### *Accomplishments*

The ESE Education Program has laid the foundation for meeting the new challenges in STEM and geography education. The establishment of the *Earth System Science Fellowship Program* for graduate research education in 1990 signaled the start of formal education programs within the Earth Science Enterprise. Following, the *Earth System Science Education (ESSE)* program (1991-2000) supported the development of Earth system science courses and curricula at 44 leading research universities. Building on *ESSE*, *Earth System Science Education for the 21<sup>st</sup> Century (ESSE 21)*, a new initiative begun in 2002, has an expanded focus on reaching out to smaller colleges and Minority Serving Institutions in their efforts to develop Earth system science courses and degree programs.

The *GLOBE* program, begun in 1994, is an international, hands-on K-12 education and science program which unites students, teachers and scientists worldwide in Earth system research. The *Earth System Science Education Alliance*, initiated in 1999, has offered online graduate level Earth system science courses to over 400 pre- and in-service K-12 teachers. As a mechanism for sharing high-quality ESE educational resources with the broader community, the *Learning Resources Evaluation* program was initiated in 1995 to provide an independent peer review of learning resources. Products passing the review are disseminated to state level teacher educators through professional development workshops. The ESE is collaborating with the *Digital Library for Earth System Education* to establish a special ESE collection for broader dissemination.

Earth Science Enterprise investments in informal education include media broadcast, museums and youth groups. *Earth Talk* (2000-2003) offers short radio broadcasts on over XXX radio networks highlighting Enterprise scientists and their research. *Eyes on the Earth*, an interactive traveling museum exhibit which helps people understand how satellites are used to study Earth, will be on display at XX museums over the next three years. *Global Climate Change and You* is workshop series for Girl Scout leaders. Through field work and hands-on activities, leaders develop the skills and experience needed to confidently engage their troops in Earth system science.

Each of these programs has in place an infrastructure for sharing resources within specific communities and networks. As the need for ESS education continues to grow, we

seek to expand our efforts so that the resources committed to individual programs are systematically leveraged to reach broader audiences. Toward this end, the ESE is working to establish a national architecture for linking communities and resources.

## 2. GOAL and OBJECTIVES

The Education Enterprise has a leading role in NASA's mission *to inspire the next generation of explorers*. In direct support of Education Enterprise efforts, the goal of the Earth Science Enterprise Education Program is *to inspire the next generation of Earth explorers*. Similarly, the objectives of our program directly support the objectives of the Education Enterprise. The tables which follow each of our educational objectives summarize Earth Science Enterprise contributions to Education Enterprise objectives and outcomes. Items marked with a shaded circle (●) indicate full support of the ESE Education Program to Education Enterprise outcomes. Those marked with an unshaded circle (○) indicate partial support of Education Enterprise outcomes while those marked with an X are not currently supported by the ESE Education Program. Following the framework provided by the Education Enterprise, objectives are structured for three educational venues (Elementary and Secondary Education, Higher Education, and Informal Education) and include cross-cutting objectives (Underrepresented and Underserved, and Educational Technology).

### *Elementary and Secondary Education*

**Objective:** Draw upon the compelling nature of Earth system science to promote student achievement and enrollment in STEM and geography courses.

Support of Education Enterprise Objectives and Outcomes	ESE Contribution
<b>Elementary and Secondary Education: Objective 6.1:</b> By 2014, in order to increase participation in post-secondary education stem disciplines, increase by 10% the number of students exposed and involved in NASA related STEM disciplines by developing support systems in targeted elementary and secondary schools.	
<b>Outcome 6.1.1: Student Support</b> By 2008, increase by X%, student participation in instructional and enrichment activities targeting NASA related STEM disciplines.	X
<b>Outcome 6.1.2: Educator Support</b> By 2008, increase by 10% the number of elementary and secondary educators utilizing NASA-related STEM materials and programs in the classroom.	●
<b>EE Outcome 6.1.3: Family Support</b> By 2008, increase by x% family involvement in NASA sponsored elementary and secondary education programs.	X
<b>Outcome 6.1.4: Institutional Support</b> By 2008, increase by X% the number of NASA elementary and secondary programs that are aligned with state STEM educational objectives.	●

Science education research indicates student achievement improves when students are engaged in activities of personal and everyday importance (REFS). Earth system science presents familiar and relevant content thereby providing a highly motivational vehicle for engaging students in science, technology, engineering, mathematics and geography. Through *GLOBE*, the tools of Earth system scientists—instruments for obtaining ground-based measurements of geophysical parameters (e.g. soil moisture, aerosol optical depth,

water salinity) and internet technology for processing and sharing data—are brought to students and teachers across the nation and the globe as they interact with scientists to study the Earth system. To date, two states, North Carolina and Texas, have signed an agreement with *GLOBE* for statewide adoption of *GLOBE* protocols. Several other states are preparing for statewide adoption. Over the next 10 years we anticipate significantly increasing the number of states adopting *GLOBE*. Together the Learning Resources Evaluation and the NASA Educator Professional Development workshops provide NASA AESP and ERC Educators with the most recent peer reviewed learning resources for distribution through stated-based networks. As we continue our program, we anticipate incorporating the use of a standardized metadata template for the development of ESE resources to ensure consistency among all resources and expanding the channels through which ESE resources disseminated by participating in state-based alliances and joining existing distribution networks.

### *Higher Education*

**Objective:** Ensure the continued training of a highly qualified and diverse workforce to support Earth system science research and Earth science applications.

Support of Education Enterprise Objectives and Outcomes	ESE Contribution
<b>Higher Education: Objective 6.2:</b> By 2014, strengthen NASA's involvement in higher education to: to enhance the nation's science and technology capacity in NASA related fields, and meet NASA's future personnel needs.	
<b>Outcome 6.2.1:</b> By 2008, increase and strengthen partnerships with post-secondary institutions to enhance the number of NASA-related academic programs and the number and diversity of students graduating in NASA related fields.	●
<b>Outcome 6.2.2:</b> By 2008, increase the number and diversity of post-secondary institutions and faculty that have the capacity to compete for NASA research and development awards.	○
<b>Outcome 6.2.3:</b> By 2008, establish a NASA-wide approach to foster interdisciplinary and institutional partnerships that will enhance the science and technology knowledge of future educators.	●
<b>Outcome 6.2.4:</b> By 2008, in concert with the scientific/technical Enterprises, increase the number and diversity of students conducting research utilizing unique NASA assets.	●

The nurturing of a highly qualified and diverse workforce is critical to expanding our understanding of the Earth system and to applying research results for socioeconomic benefit. The Earth Science Enterprise continually expands our knowledge of Earth system processes and systematically endeavors to apply research results and Earth observation information products to the twelve applications of national priority (carbon management, energy forecasting, aviation safety, public health, water management, homeland security, coastal management, disaster preparedness, air quality, community growth, invasive species and agricultural competitiveness). The workforce in research and application represents a broad array of professionals with careers in Earth system research, forest management, agriculture, water resource management, marine fisheries, public health and aviation flight support, to name just a few. Over the long-term, Enterprise contributions to the formal education pipeline—through the ESS Fellowship, ESSE 21, MSPHD's, NIP



programs as well as new initiatives—will continue to have a profound impact on ensuring a competitive workforce capable of approaching tasks from an interdisciplinary perspective for careers that rely on environmental information economy.

*Underrepresented and Underserved*

**Objective:** Reach out to and support underrepresented and/or underserved communities through each sponsored education program.

Support of Education Enterprise Objectives and Outcomes	ESE Contribution
<b>Underrepresented and Underserved: Objective 6.3:</b> Establish and continually improve support systems that annually increase the number and diversity of STEM students, teachers, faculty and researchers from underrepresented and underserved communities.	
<b>Outcome 6.3.1: Student Support:</b> By 2008, increase the number and diversity of underrepresented/underserved NASA-sponsored students who are pursuing academic degrees in NASA-related STEM disciplines through pre-college programs, scholarships, and internships.	●
<b>Outcome 6.3.2: Faculty Support:</b> By 2008, increase the number and diversity of teachers and faculty from underrepresented/underserved communities and institutions who are contributing to NASA-related STEM learning environments through fellowships, stipends, pre-service and in-service training programs.	○
<b>Outcome 6.3.3: Support to Researchers and Institutions:</b> By 2008, increase the number of underrepresented/underserved researchers and Minority Serving Institutions that successfully compete for NASA Research Announcements (NRAs) and grants.	○
<b>Outcome 6.3.4: Family Support:</b> By 2008, increase underrepresented/underserved family involvement in NASA-sponsored programs.	X

Our nation's population is a diverse one. As we enter the 21<sup>st</sup> century, the demographics of our K-12 student body are changing to reflect the changing diversity of our national population. As the aging population of Earth system science professionals nears retirement, it is this diversity that will be counted upon to bring new perspectives and new talent to the Earth system science research, application, technology and education. In conjunction with NASA's efforts to ensure that women, racial and ethnic minorities, socioeconomically disadvantaged persons and persons with disabilities are given equal opportunity to participate in NASA Education programs, the Earth Science Enterprise Education Program works to ensure that these populations have equal access to our portfolio of elementary and secondary, higher education, and informal education programs.

*Education Technology*

**Objective:** Infuse education technology throughout education programs.

Support of Education Enterprise Objectives and Outcomes	ESE Contribution
<b>Educational Technology: Objective 6.4:</b> By 2014, develop and fully implement the infrastructure of e-education as a learning support system for NASA's elementary/secondary, higher education and informal objectives.	

<b>Outcome 6.4.1: Education Technology R&amp;D:</b> By 2008, increase the research, development, and evaluation of new techniques and technology applications for use by researchers, educators, students and families.	●
<b>Outcome 6.4.2: Learning Tools and Materials:</b> By 2008, provide educators with unique teaching tools and experiences that are aligned with national standards for STEM content areas.	●
<b>Outcome 6.4.3: Digital Learning/Content Services:</b> By 2008, provide the technology, connectivity, content and human resources that allow more Americans to be <u>directly</u> involved in the NASA mission than before.	●

Educational technology: 1) technology provides valuable opportunities for developing innovative pedagogies for engaging students in inquiry-based learning; 2) helps students develop the technology skills needed to be competitive in the workforce relevant to Earth system science.

#### *Informal Education*

**Objective 1:** Provide engaging Earth system science content and human resource support to informal learning institutions for the benefit of all students.

**Objective 2:** Cultivate citizens' abilities to get the data, resources and information they need to satisfy their own curiosity on how the Earth system works and/or take actions to meet individual or societal needs.

Support of Education Enterprise Objectives and Outcomes	ESE Contribution
<b>Informal Education: Objective 6.5:</b> By 2014 provide engaging NASA content and human resource support to informal learning institutions for the benefit of all students.	
<b>Outcome 6.5.1: Instructional Materials:</b> By 2008, NASA will provide instructional materials derived from NASA research and scientific activities that meet the needs of NASA's informal education partners.	●
<b>Outcome 6.5.2: Professional Development:</b> By 2008, NASA will provide professional development for NASA's informal education partners based on needs assessment results.	●
<b>Outcome 6.5.3: Intergenerational Learning Experiences:</b> By 2008, provide NASA content and expertise that will facilitate intergenerational learning experiences.	○
<b>Informal Education: Objective 7.1:</b> By 2014 provide NASA content and human resources to increase public knowledge and understanding of the NASA research and exploration mission and its benefits to the United States and the world.	
<b>Outcome 7.1.1: National Campaign:</b> By 2008, NASA will be engaged in a national campaign through the informal education network to increase appreciation of the relevance and role of NASA science and technology.	○

NASA artifacts are among the top attractions at many science and technology museums across the country, and NASA missions are continuously providing new understandings of earth system processes – from understanding ocean circulation using TOPEX/Poseidon to the possibility of locating new underground aquifers using the GRACE satellite ...ICESAT....Aqua. The Earth Science Enterprise will continue to make breaking news available to these institutions available as well as the latest imagery from missions such as Aqua, ICESAT....

The increasing complexity of today's earth system science issues challenges us to provide engaging resources to the public (much more than available in newspapers/media) so that they can undertake their own investigations to study earth system processes. The Earth Science Education will continue to develop innovative technologies which allow the public to visualize and analyze their own data.

The public increasingly draws upon Earth system knowledge when participating in policy decisions which impact our quality of life, the national economy and the overall health of the planet. From land use to water management to global climate change, informed and reasoned decision making requires consideration of the scientific, technological and societal perspectives of Earth system science. Education, law, policy, entertainment and other professionals have a responsibility and obligation to participate in maintaining and improving the overall health of the planet. The Earth Science Enterprise continues to prepare students for responsible action by providing opportunities for students, regardless of future career choice, to participate in and develop an appreciation for the multiple dimensions of Earth system science.

The anticipated impact of the successful achievement of these objectives is the continued growth of a broad, diverse and cohesive Earth system science education community. Over the long term, we anticipate widespread public literacy about the Earth system and the environment and the maturation of a highly competitive workforce for Earth system science research, application, technology and education.

#### *Overriding Principles*

The success that ESE has achieved in education with limited resources is well rooted in the overriding principles established in the 1996 Education Strategy; these principles have proven useful in guiding the development and implementation of our educational endeavor. Similar principles have recently been codified for the Agency under the leadership of the Office of Education. The "Criteria for Exemplary NASA Education Programs" is a collaborative effort by the Office of Education, the Education Leads from NASA's five scientific/technical Enterprises, and the Education Directors from all of the field installations. They are:

- Customer Focused
- Content
- Pipeline
- Diversity
- Evaluation
- Partnership/Sustainability

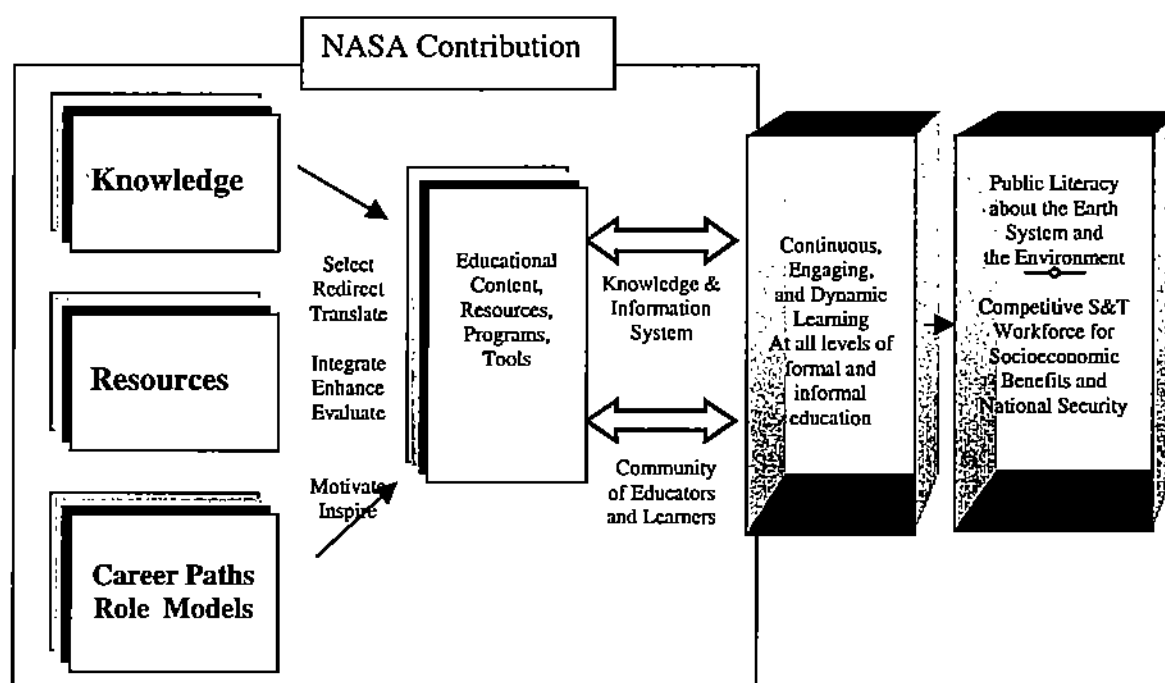
A more extended description of these criteria and respective elucidation in elementary/secondary, higher, and informal education is included in Appendix A.

### **3. APPROACH**

Agency and national emphasis on STEM education in general and Earth system science education in particular coupled with the ESE knowledge, data and content resources demands a systems approach for leveraging resources and reaching the broad education

communities. Our approach is to provide an architecture for systematically raising awareness of, facilitating access to, and encouraging participation in Enterprise activities by a larger percentage of educators at all levels of formal and informal education. This architecture embodies two overarching and interrelated networks. The first is a networked knowledge discovery and information system. The second is a networked Earth system science education community. The anticipated outcome of our new systematic approach is continued development of a broad and diverse community of learners actively involved in the physical, chemical, biological and societal dimensions of Earth system science. The anticipated impact of this systematic approach is an increase in public literacy of the Earth system and a competitive Earth system science and technology workforce.

#### From ESE R&D to Education 2003-2012



Approach: Create a national architecture that enables scalable, systemic, and sustainable solutions to Earth System Science education

### 3.1. Networked Knowledge Discovery and Information System (“Earth Knowledge Gateway”)

#### (REASoN awards)

The Earth Knowledge Gateway (EKG), under development by the Earth Science Enterprise, is a flexible and dynamically updated web interface to scientific knowledge about the Earth. This EKG will play a critical role in providing equity of access to ESE information for the entire ESSE community and is imperative to continued community

building. The EKG is intended to meet the needs of a diverse stakeholder community including educators, students, researchers, employers, policy makers, applied users, and the science attentive public. Currently, the Enterprise collects over 1.5 TB of information each day from the unique vantage point of Earth orbit using 80 sensors from 18 Earth observing spacecraft. Over 2000 research grants annually support the work of thousands of civil service, contractor, university, non-profit and industry personnel to further our understanding of how the Earth works—the results of which are all potential resources for the Earth system science education community. The volume of information available for educational uses is enormous and enormously complex. The EKG will provide a simple, yet effective means to explore, discover and utilize the resources being developed by the Enterprise. At the same time, EKG will provide a structured link to Earth system knowledge developed and held beyond NASA, such as by federal and state agency partners, and the international global change community.

The EKG within the education community is best described by scenarios....

A teacher using EKG

Able to pull visuals in real time or near real time

Learns about GLOBE or Windows to the World

A student using EKG

### **3.2 Networked Earth System Science Education Community**

At the heart of the ESE education program is people. Successful implementation involves actively engaging students, educators, scientists, families, community members, educational professionals, members of professional societies, education administrators, employers and academics as well as other Federal agencies and institutions in the Earth system science education community. The intent of the education program is to facilitate interaction and collaboration among stakeholders committed to systemic change for Earth science education through the collaborative development and systemic dissemination of Earth system science educational resources, programs and products.

The growth of the internet provides a tremendous opportunity for expanding and building cohesion within the Earth system science education community by providing a mechanism for people with a shared vision and focus who are geographically (and sector/socially) separated. The ESE anticipates the continued development and expansion of existing networked communities within.....There are a number of aspects that we intend to put in place????

## **4. Measures**

(input, output, outcomes)

- Budget, current investments
- At least ??% of Kids/Students/Educators sections of the NASA Portal
- Metrics/attributes of “networking” from REASoN awards
- Content to dissemination
- Number of partnerships
- Diversity

## 5. Management

All elements of NASA work together to achieve the Agency goals, as demonstrated in the NASA Strategic Plan (2003).

### Governance

- Focus Area Reviews, with Education/Outreach as an integral part of the programs/missions/projects
  - Relation with Outreach
- Earth Science Education Lead as a member of the leadership in Code N, co-located in Code Y fulfilling Earth Science program responsibilities and serving as the bridge between Y and N

### Management initiatives

- Annual report of Earth Science Education and Outreach
- Appendices B &C

## **Appendix A. Criteria for Exemplary NASA Education Programs**

<b>Criteria 1: Customer Focused</b>	
Programs/products have been designed to respond to a need identified by the education community, a custom or customer group	
<b>All</b>	Contributes to NASA research and development objectives
<b>K-12</b>  Students Educators Organizations	Supports “All students taught by quality teachers...” (No Child Left Behind Act 2002)
	Educational content is scientifically accurate, age and grade-level appropriate
	Helps students develop essential mathematics and science skills
	Provides professional development activities
	Helps teachers integrate technology into the subjects they teach
	Provides organizations with teaching tools and compelling enterprise related experience to motivate and inspire students and teachers
	Evident connection to national and/or state standards
<b>Higher Ed</b>  Students Educators Organizations	Help students develop essential mathematics and science skills in support of STEM
	Provide opportunities for institutions to create scientific entities in support of NASA research
	Strengthen capacity to fully complete for NASA contracts, grants, cooperative agreements, and other federal opportunities
<b>Informal Ed</b>  Students Educators Organizations	Strengthen the connections between schools and families
	Helps informal education institutions deepen and enrich contents of their programs and exhibits in aerospace related subjects
	Promote careers in science, mathematics, engineering, and technology

<b>Criteria 2: Content</b>	
Programs/products are directly tied to or make direct use of NASA content, people or facilities to involve students and/or the public in NASA science, engineering, or technology	
<b>All</b>	Reflects “as only NASA can” by promoting NASA’s uniqueness and effectively representing NASA enterprises, missions, programs and projects
<b>K-12</b>  Students Educators Organizations	Informative learning for students and teachers about NASA content in support of STEM
	Promotes careers in science, mathematics, engineering and technology
	Programs and products support systemic reform for improvement of student proficiency
<b>Higher Ed</b>  Students Educators Organizations	Provides a model for ensuring that teachers/students participate in actual NASA-based science, technology, and research opportunities
	Provides opportunity for institutions to develop college level courses using NASA content



<b>Informal Ed</b>  Students Educators Organizations	Reflect the technology and focus of NASA enterprises
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<b>Criteria 3: Pipeline</b>	
Programs/products have made a demonstrable contribution to attracting diverse students to NASA careers in science, technology, engineering, or mathematics	
<b>All</b>	Serves NASA and/or aerospace industry and universities
<b>K-12</b>  Students Educators Organizations	Excites students and teachers to participate in NASA education and intern programs
	Creates linkage to other NASA programs relating to the career/inspiration theme
<b>Higher Ed</b>  Students Educators Organizations	Creates linkage to other NASA programs relating to the career/inspiration theme
	Develops a candidate pool of underrepresented minorities and/or people with disabilities to participate in NASA pre-employment scientific and technical programs
	Channels students into NASA related disciplines to NASA, Universities and Private Industry
<b>Informal Ed</b>  Students Educators Organizations	Has NASA content that enriches the educational experience

<b>Criteria 4: Diversity</b>	
Programs/projects reach identified targeted groups	
<b>All</b>	Targets underrepresented minorities and/or people with disabilities to participate in NASA pre-employment scientific and technical programs
<b>K-12</b>	Supports closing the gap in science and mathematics proficiency among diverse populations
<b>Students Educators Organizations</b>	Emphasizes recruitment of targeted pre-service and in-service populations to participate in NASA educator programs
	Promotes careers in science, mathematics, engineering and technology
	Increases the interest of minority students to take academic courses in NASA – related subjects
<b>Higher Ed</b>	Promotes opportunities for faculty at minority serving institutions to engage in research opportunities consistent with NASA's requirements
<b>Students Educators Organizations</b>	Provides opportunities for: <ol style="list-style-type: none"> <li>1. Minority serving academic institutions</li> <li>2. Minority faculty at non-minority institutions to strengthen their capability to conduct collaborative research that contributes to NASA</li> </ol>
	Encourages minority serving academic institutions to include scientific literacy requirements in their teacher education curriculum
<b>Informal Ed</b>	Provides awareness and understanding through culturally appropriate programming to targeted communities of how NASA's research and innovations in aerospace technology affect and improve the quality of life for all citizens
<b>Students Educators Organizations</b>	

<b>Criteria 5: Evaluation</b>	
Programs/products have goals expressed in an objective, quantifiable, and measurable form	
<b>All</b>	Performance goals define the level of performance to be achieved
<b>K-12</b>	Evaluated regularly by external and internal sources and has built in mechanisms for making adjustments
<b>Higher Ed</b>	Has a basis for comparing actual program results with the performance goals, along with a description of the means to be used to verify and validate measured values
<b>Informal Ed</b>	

Students Educators Organizations	Results in demonstrated their value and usefulness to the education community (and their potential for replication, transportability, and sustainability) by being adopted and used in a continuing way in substantial numbers of educational institutions across the country, through reaching large audiences, or through the receipt of major awards or other significant forms of external recognition
	Results in making demonstrable progress towards involving minorities and minority institutions in NASA-related work, and/or developing NASA-related academic or research capabilities at minority colleges and universities

<b>Criteria 6: Partnerships/Sustainability</b>	
Programs/products achieve high leverage and sustainability through intrinsic design or the involvement of appropriate local, regional, or national partners in the design, development, and dissemination	
All  K-12  Higher Ed  Informal Ed  Students Educators Organizations	Lends itself to partnerships internal and external to NASA
	Sustainable beyond initial NASA funding
	Supports "...partnership agreements with state colleges, universities and community colleges and school districts, with the goal of strengthening K-12 math and science education...." (No Child Left Behind Act 2002)
	Replicable for use in the majority of all geographic and economic locations
	Based on defined roles and responsibilities for all parties
	Reflects partnerships that allow for NASA's unique contribution while reflecting the importance of others' contribution to overall success
	Follows all NASA's guidelines

**Appendix B. Directory of ESE Education and Outreach Activities and Products****Categories****Elementary/Secondary Education**

- Development and/or dissemination of curriculum support materials
- Teacher preparation and/or enhancement
- Student support
- Systemic integration

**Post-secondary Education**

- Development and/or dissemination of curriculum support materials
- Educator professional development
- Student research

**Informal Learning Centers** (museums, science and technology centers, planetariums, zoos, etc.)

- Shows, exhibits, etc.
- Professional development

**Natural and Cultural History Sites** (national or state parks, nature centers, historical monuments, etc.)**Multiple media** (radio, TV, films, print, internet, games, etc.)**Youth and Community Groups** (scouts, 4-H, citizen scientists, civic organizations, etc.)**News****Peer or Intermediary Communication****Executive Outreach** (policy-makers, opinion-shapers, ????????)

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Each entry contains some or all of the following information:

**Title:****ESE Focus Areas:**

- Climate Variability & Change
- Atmospheric Composition
- Carbon Cycle and Ecosystems
- Water and Energy Cycle
- Weather

- Earth Surface and Interior

**Subject(s):**

**Physical Format(s):**

**Audience:**

**Mission(s)/Program(s):**

**Lead:**

**Contact Information:**

**Primary URL:**

**Secondary URL:**

**Partner(s):**

**Description:**

Narrative description of the product or activity

**Scientist(s):**

**Event(s):**

**Appendix C. Education and Outreach Directory of ESE Missions and Programs****Title:**

Name of the mission or program

**Description:**

Overview of the education and/or outreach conducted by the mission or program

**Lead:**

Person or organization with lead Education and/or Outreach responsibility for the mission or program

**Contact:****URL:****Activities (or Awards):**

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The listings are grouped into categories as follows:

**Earth Science Enterprise**

Major Partnerships

“Overhead/burden” at the Centers

**Program Planning and Development (UPN .....)**

EOS

- Terra, Aqua, Aura

TRMM

ESSP

- GRACE, OCO, Aquarius, HYDROS

NPOESS

Landsat Continuity Mission

Earth Science Technology

....

**Earth System Science (UPN .....)**

Interdisciplinary Science

Terrestrial Ecology

.....

**Earth Science Applications (UPN 613, .....)**

Aviation Safety

Public Health

.....

**Earth Science Outreach (UPN 635)****Earth Science Education (UPN 631, 292)**

K-16/Informal Education

Earth System Science Fellowship Program (graduate)

New Investigators Program in Earth Science (early-career)



# Elementary & Secondary Education Roadmap: Toward Improved Student Achievement & Enrollment in STEM including Geography

Partners: NSF, Depart. of Education, USGS, NSTA, NESTA, ITEA, AGI, Publishers

DRAFT

Diverse student body attracted to STEM

Learning About the Earth System

Collaborate with Education Enterprise and professional societies to contribute to state-based alliances for the purpose of integrating Earth system science into STEM curricula, standardized testing and textbook development.

Professional development of teachers as advocates for integrating Earth system science into STEM and geography education.

Develop multilingual resources to reach an increasingly diverse population

Partner with digital libraries to disseminate opportunities and resources through electronic networks

Partner with professional societies to disseminate opportunities and resources through existing teacher networks (e.g. Building a Presence).

Continued adoption of GLOBE protocols at state level

Partner with NSF to integrate Earth system science education research into science education research base.

Increased innovation for integrating technology into STEM and geography education within an Earth system science context (REASoN).

ESE data sets inter-operable and readily accessible for use in education (Open GIS Consortium Data Buy, Data Pool, DAACs)

Development of metadata based templates to ensure consistency among ESE resources (NSF/DLESE)

Continuous, engaging and dynamic learning

2003

2005

2007

2009

2011

2013

Ongoing Programs: GLOBE, Mission Geography





# Higher Education Roadmap: Toward a Diverse and Highly Qualified Earth System Science Workforce

Partners: NSF, USGS, EPA, AGU, ESA, AMS, AAG

DRAFT

Competitive Earth System Science Workforce for Socioeconomic Benefits and National Security

Learning About the Earth System

ESE resources for undergraduate and graduate education fully accessible through DLESE. Resources shared and used throughout education community

Partner with professional societies to offer special sessions and workshops on ESS education

Partner with digital libraries to disseminate opportunities and resources through electronic networks

Earth system science education integrated into science education research base

Simplified, web-based ESS models of geophysical processes routinely used in undergraduate and graduate research and education

Catalogue of ESS models and accompanying metadata

ESE data routinely and dynamically integrated into undergraduate and graduate research and education

Partner with industry to integrate ESE applications into undergraduate and graduate education

ESE data sets inter-operable and readily accessible for use in education (Open GIS Consortium, Data Buy, Data Pool, DAACs)

Development of metadata-based templates to ensure consistency among ESE resources (NSF/DLESE)

Current trajectory:

Steady improvement in: use of ESE data and models in disciplines relevant to Earth System Science, training of interdisciplinary scientists, competitive workforce, and innovative pedagogies for Earth system science education

Continuous, engaging and dynamic learning

2003

2005

2007

2009

2011

2013

Ongoing Programs: ESS Fellowship, NIP, ESSE 21



# **Informal Education Roadmap: Toward Providing Engaging Earth system science content and human resource support to informal learning institutions for the benefit of all students.**

Partners: Industry,  
Museums??????

**DRAFT**

Public literacy about the  
Earth system and the environment

Learning About the Earth System

Develop multilingual resources to reach an increasingly diverse population.

Ongoing training of the professional workforce in the applicability of ESE data and models to industry.

Simplified, web-based ESS models of geophysical processes routinely available at informal learning institutions.

ESE data analysis tools available over the web for use in homes and informal learning environments (IGETool).

Increased involvement of citizen scientists, community organizations and youth groups in informal learning of the Earth system.

Simplified, web-based ESS models of geophysical processes  
routinely available at informal learning institutions.

NASA University for Earth system Science Education.

ESE data sets inter-operable and readily accessible for use in education.  
(Open GIS Consortium Data Buy, Data Pool, DAACs)

Development of metadata-based  
templates to ensure consistency  
among ESE resources  
(NSF/DLESE)

Continuous, engaging and dynamic learning

2003

2005

2007

2009

2011

2013

REASON CAN  
ESSEA

REASON CAN  
Pending